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FINAL REPORT

THE EVALUATION OF AVAILABLE METHODS FOR THE HUMANE REMOVAL OF VELVET ANTLERS

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THE COMPARISON OF TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION (TENS) VS A LOCAL ANESTHETIC FOR BLOCKING PAIN DURING THE HARVESTING OF VELVET ANTLER FROM BULL ELK

Final Report

by

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Introduction

The harvesting and sale of velvet antler from elk has been a major economic factor in the profit and growth of the elk industry. Harvesting involves amputating the entire soft antler above the pedicle during a stage of development when the antler is still growing. Based on the extreme measures a stag will take in order to protect his growing antlers (Pollard et al 1992) and research demonstrating that denervation of the antler makes it prone to injury through loss of spacial awareness and sensation (Wyslocki and Singer, 1946), this highly innervated vascular tissue is considered to have a high degree of sensitivity. Research using immunohistochemical techniques have been used to demonstrate that antlers are innervated mainly by sensory nerves (Gray et al., 1992).

Previously, producers have sedated the animals or provided general anesthesia during antler harvest, but concerns about animal recovery along with innovations with facilities and hydraulic squeezes have eliminated the need for chemical restraint. A widely accepted method of antler removal involves mechanically restraining the animal, applying a tourniquet at the base of the antler and injecting local anesthetic to block the pain during the removal (Woodbury and Haigh, 1996). In North America, whole body electro-immobilization (EI) was explored by the industry as a method of restraint for antler harvesting and as an alternative to sedation and anesthetics. However, whole body EI for restraint in sheep and cattle had received negative reports (Grandin et. al., 1986; Rushen, 1986) and has fallen out of favor for use in elk. Elk producers have moved away from whole-body electro-immobilization to a more localized approach. The most recent development in the elk industry has been the use of a TENS (Transcutaneous Electrical Nerve Stimulation) device applied to the base of the antler or from the ear to the base of the antler to establish a nerve block during antler harvest and used in combination with mechanical restraint. The TENS device has some history of success for minor procedures in human dentistry and for treating chronic pain in human patients. However, TENS has

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been reported to have a wide variability in its effectiveness in blocking pain in human patients.

This report investigates the efficacy of nerve blocks by local anesthetic injection and TENS as compared to no nerve block. It is hoped this study may provide more insight into the most effective method of humane antler removal.

Project Objectives:

1) Determine if the behavioural response during antler harvest in bull elk varies depending upon the technique used to block pain.
2) Determine if subsequent behaviour during handling and recapture after antler harvest is influenced by previous harvesting technique.

Animals, materials and methods

Sixty-two mature bull elk, ranging in age from 3 to 9 years, were used in this study. The elk were kept in a pasture prior to harvesting and were herded in small groups using all-terrain vehicles into the handling facilities. No group was held for more than 2 hours within the handling area before harvesting and all animals were experienced with the handling facility. The handling area consisted of a rotunda system with five compartments adjacent to the common holding area. After being sorted from a larger yard area animals were brought into the central area either alone or in pairs. Animals were moved from the central holding area with the use of swinging gates. Once in the holding area they were further sorted into adjacent compartments. The animals, in turn, were gently pushed into the squeeze chute with the use of swinging gates.

A rigid box-like chassis embodied the functional components of the chute. The open-top chassis measured 2.7 m long, 1.5 m wide and 2.4 m high. The chute set directly on the ground with sandy-soil forming the floor. Each side of the chute consisted of a panel 1.2 m high and 2.7 m long. The sides were hydraulically operated and could be moved in both a horizontal and vertical direction. The top edges of the side panels were padded to avoid injury to the animal during catching and restraining. Sheets of heavy denim fabric were draped from the top of the chassis the entire length of the chute, serving as a flexible and moveable blind to allow access to the head during harvesting. Both ends of the squeeze were manually-operated solid-panel sliding doors.

Once an animal was maneuvered into the chute it was caught in the squeeze with its head up; the sides of the chute hydraulically adjusted to catch just below the mandible of the jaw. It was further restrained with a halter placed around the nose and head and a towel was placed over the animal's eyes. Two ropes attached to the halter were secured to either side of the chute. A 500-lb load cell was placed between the rope and the chute on both sides in order to measure the force and movement of the animal. A triaxial accelerometer was secured across the nose-band on the halter, in order to measure the movement of the nose of the animal (Figure 1). It was capable of measuring the acceleration of the animal's head in three directions. All measurement devices were used to objectively quantify the animal's struggle and movement during the cutting of the soft

antler. The movement was considered an indicator of the animal's effort to escape the procedure.

A power supply/signal junction box (ps/sj box) was constructed to supply the load cells and accelerometer with power and to receive and assemble the output signals from the instruments. The ps/sj box also contained four switches that governed another voltage output used as a trigger to start and stop data acquisition and served as a marker to identify different stages of the procedure. Each switch produced a different voltage output, allowing a range of trigger/marker levels to signal the start or stop of various stages of the harvesting procedure. The ps/sj box was supplied with 12 v @ 250 mA by a transformer receiving 60 Hz V a/c power. The box contained voltage regulators that sent 5 V to each load cell. The ps/sj box had six output channels: two load cell signals, three accelerometer signals, and a trigger/marker signal. Each output signal was in analog form. From the ps/sj box, the six signals were transmitted to an external data acquisition card (OMB - TempBook/66, Omega Engineering Inc., Stamford, CT) via a common cable. The signals were then digitized and sent to a personal computer (Toshiba Satellite Pro 470 CDT, Toshiba Corporation, Tokyo, Japan) by a parallel port connection.

The data acquisition process was controlled by a program compiled in data acquisition software (Labtech Notebook, Laboratory Technologies Corporation, Redmond, WA, 1996). Using a sampling frequency of 20 Hz, the program was triggered by toggling a switch on the ps/sj box.

Following a random (but predetermined) treatment order each elk was assigned upon entry into the chute to either 1) Lidocaine injection (n = 20) applied prior to antler removal, 2) transcutaneous electrical nerve stimulation (TENS) (n = 21) applied before and during antler removal, or 3) control with no chemical or electrical analgesia during antler removal (n = 21).

Animals in the Lidocaine treatment group received Lidocaine injections administered in either a ring block (n = 16) or a three point regional nerve block (n = 4) as described by Woodbury and Haigh (1996). These techniques are reported to cause local anesthesia of the infratrochlear and zygomaticotemporal branches of the opthalmic division of the trigeminal nerve believed responsible for the enervation of the soft antler. A 2% Lidocaine[5] preparation, without epinephrine, was mixed with 8.4% sodium bicarbonate[6] to buffer the solution. This combination was used to reduce tissue irritation, avoid tissue necrosis and facilitate movement of lidocaine across the nerve's outer membranes. A total of 15-20 ml of Lidocaine was injected into 6-8 separate sites equally spaced around each pedicle to establish the ring block. Alternatively, 10-15 ml were injected to obtain the three point regional nerve block (Woodbury and Haigh, 1996). It took between 45 and 95 sec to administer a ring block around each antler and between 35 and 45 sec to complete a three point block. (Two different Lidocaine injection procedures were followed due to two different personnel being present on various days; both procedures are believed to cause the same analgesic effect.) Following the Lidocaine block for the first antler, a 5 min wait period was observed to allow the anesthetic to take affect. During the 5 min wait the second antler was blocked. Since the two antlers were cut in

[5] 2% Lidocaine hydrochloride Injection USP. 20mg/ml. Bioniche, Inc. London, ON Canada N6M 1A3
[6] 8.4% Sodium Bicarbonate Injection USP. 4.2 g/50ml. Abbott Laboratories, Limited, Montreal, Canada.

quick succession and it required less than 10 sec to cut the first antler, the second antler was normally cut before 5 minutes had elapsed. Prior to cutting, a tourniquet was placed around the pedicle of the antlers and isopropyl alcohol (70%) was sprayed on the area the saw would cut. An electric reciprocating saw was used to remove the antlers approximately 1 cm above the pedicle. The power saw was used in favor of a handsaw to help reduce the load cell signal variations caused by hand-sawing motions.

Animals on the TENS treatment were restrained and connected to the TENS device by placing two electrode leads with alligator clips onto the lateral margin of each ear, as close to the skull as possible. The TENS machine was operated by the same person each time to ensure consistency in operation and stimulation level. The level of the TENS' current was gradually increased until the animal's ears twitched and then slightly reduced. The current was intermittently increased over a period of 2 minutes until sufficient anesthesia was obtained as determined by the experienced operator. The operator judged the required amount of analgesia through observation of subtle changes in the animal's ear carriage and eyelid movements. The tourniquet and alcohol were administered and the antler removed using the same protocol as described for the Lidocaine treatment.

Animals in the control treatment group were randomly assigned to one of two control treatments. One control group was caught in the squeeze and restrained for two minutes before cutting without the use of any analgesic (n = 10). This treatment was to simulate the waiting time that was normally required for the TENS device to deliver the appropriate block. The other half of the control group had their antlers cut immediately after the animal had been restrained and the halter, with the load cells, was secured (n = 11). This control was used to determine what effect waiting per se may have had on the animal's response. Again the same protocol for the removal of antlers was used. There was no control group that directly simulated the waiting period of the Lidocaine treatment group.

The control treatments were deemed necessary to determine if the handling and restraint procedures alone would stimulate a response capable of masking the animal's overt behaviour to antler harvesting. In other words, we were interested in determining if it was possible for animals to show no response to antler removal simply because the stress of handling and restraint overrode the pain sensation.

Signals from the load cells were recorded directly by computer. Baseline measurements of 5 sec duration were taken for each animal in order to determine the initial force being exerted by the animal prior to the cutting of the antler. The baseline measurements also recorded the response of the animal to the injections, the attachment of the alligator clips, the voltage adjustments of the TENS device, and the sound of the electric saw running for 5 sec while held in close proximity to the animal's head. The beginning and ending of each procedure and the exact start time when cutting took place was marked with a switch. This enabled all of the portions of the procedure to be clearly identified. A switch was also used to mark the end of the cutting procedure.

When each antler removal was completed, the data were stored in a file that could be retrieved onto a computer spreadsheet (Microsoft Excel, Microsoft Corporation, Redmond, WA). The elapsed time was recorded in seconds, and the acceleration and trigger/ marker values in volts. The voltage outputs from the load cells were converted to force values (Newtons) by a calibration equation in the data acquisition software. Prior to the experiment, a calibration was performed on both load cells using forces ranging from 0 to 2000 N (Instron Model 1011, Instron Corporation, Conton, Mass).

The actual data that were recorded during the pre-cut and harvesting periods represented a continuous string of digitized values representing the force history sensed by the load cells. Similar to methods used to rank the relative amount of struggle displayed by cattle during branding (Schwartzkopf-Genswein et al., 1997 and 1998), a single numeric value was calculated for each elk to represent the degree of struggle displayed during the cutting procedure. This value was generated by calculating the standard deviation from the baseline value of all the instantaneous force measurements for each animal. In other words, the more an animal struggled the larger the standard deviation would be above the baseline value obtained before cutting.

A total of 27 animals were recaptured after a few days of their antlers being removed to assess their aversion to being restrained, blindfolded and held within the same facility where their antlers had been removed. The time to re-enter the chute and the time to recapture the animal with its head in an upright position was recorded. Their response to the sound of the electric saw running in close proximity to the animal's head was also measured via the load cells as previously described.

Statistical analysis.

Data were analyzed using the analysis of variance procedure (Statistix for Windows, 1996) with age of elk, day of harvesting and weight of antler as covariates in the model. None of the covariates were significant and did not contribute to variance in the model. Therefore the covariates were dropped and a simple one way analysis of variance was used to analyze the results (Statistix for Windows, 1996).

Results:

During harvesting

The maximum force the bull elks exerted, as measured by the load cells, during the antler removal process and the relative amount of movement during the entire procedure are reported in Table 1. No differences were detected between the two control groups, therefore the results were combined and are represented under one Control group in Figure 2. There were no statistically significant difference in the load cell forces between the treatment groups, or between treatment groups and the control group. Although the average load cell forces appeared to be numerically different, the large amount of variation (as reflected in the large Standard Errors) within the treatments eliminated any statistical differences. Treatments did differ in the amount of time the animals were restrained during the procedure. The lidocaine treatment spent, on average, over 2 minutes longer within the squeeze than the other treatment groups due to the time delay required for the lidocaine to take affect (see Table 1).

The relative amount of struggle as measured by the exertion forces collected during antler harvesting for each treatment group is displayed in Figure 3. There were no significant treatment effects, indicating the overall amount of struggle recorded during the cutting procedure was essentially the same for all treatment groups. The lidocaine treatment group again generated the largest numerical value, but was not found to be significantly different than the other treatments.

Response to recapture

The amount of time it took the 27 elks to re-enter the squeeze area, to be re-captured within the squeeze with their head up, and the force they exerted against the load cells when re-exposed to the sound of the reciprocating saw is shown in Table 2. No differences were detected in any of the aversion parameters measured.

Discussion

Our measurements were designed to specifically investigate the response of animals at the time of cutting. We are uncertain why animals in the Lidocaine and TENS generated exertion force values as large as the control animals. In fact, the Lidocaine treatment group generated the largest numerical values, but was not found to be significantly different than the other treatment groups. An explanation for the similarity to the control treatment might be in the methodology used to harvest antler from the Lidocaine group. It was noted earlier that the second antler was normally cut before the full 5 minutes had elapsed. If anesthesia of the second antler was not achieved, then the reaction to cutting similar to the control group might be expected.

It is possible that the lack of treatment differences may be a reflection of our inability to apply a level of restraint that was consistent from one animal to the next. The methodology for measuring the elk's response to antler cutting was adopted from our work with cattle that successfully separated animals' responses to three different methods of branding (Schwartzkopf-Genswein et al., 1997 and 1998). In our previous work with cattle we collected signals from strain gauges and load cells attached to a stationary cattle squeeze and measured the horizontal and forward force the animal exerted against the chute during branding. However, in the present case, the hydraulic elk squeeze was adjusted against the animal in both a vertical and horizontal direction, while the load cells were attached to the halter placed around the animal's head rather than the chute itself. It is possible that the forces measured during the antler removal were influenced by the animal's ability to generate upward leverage. The leverage could have varied depending upon the vertical pressure of the squeeze on each animal. In hind sight it seems reasonable to suggest that the hydraulic squeeze may have provided too many variables during restraint to accurately reflect each animal's willingness and ability to struggle. We believe the load cells accurately measured the force exerted by the elk during the procedure, however the actual ability of each animal to struggle during antler removal could easily have varied, essentially negating treatment differences.

It is also possible that the handling, restraint and removal methods, in and of themselves, are stressful enough to the elk such that any additional sensation due to pain did not

evoke a measurable response. However, since the pre-cutting baseline values were consistently lower than the exertion force measurements obtained during harvesting (see Figure 4 for a typical response curve), we believe the animals were responding to some type of stimuli during the cutting procedure. However, from our data we can not determine for certain what particular sensation (pain, fear, tactile, etc.) evoked the response. The reciprocating saw was a unique auditory and tactile sensation for these animals, since previously all these elk had their antlers harvested in preceding years using a manual hand saw. So while the reciprocating saw eliminated some variation we may have obtained using a manual saw, it unfortunately represented a new and potentially frightening auditory and tactile stimuli to the elk. An avoidance response from the unfamiliar sensation of the saw may be difficult to distinguish from a response due to the pain of antler removal. Much like a person experiences the sensation of a dentist's drill even when adequately blocked by anesthetics, the elk may have responded to the sensation of the reciprocating saw against their antlers. The vibrations from the saw were clearly recorded by the accelerometer and proved to be useful indicators of the exact times the saw was in contact with the antler (see X-axis in Figure 4). The saw vibrations alone may have contributed significantly to the animal's reaction and masked a pain response. Perhaps a non-tactile noxious stimuli, such as a heat source, could be applied to the tips of antlers prior to harvesting to determine if pain sensation is possible within these treatment groups.

Other non-specific factors may have evoked a response by the restrained animals during the harvesting procedure. Typically the procedure was performed by individuals familiar to the animals and was performed under familiar circumstances. The presence of strangers or persons unfamiliar to the elk is sufficient to cause handling difficulties (Haigh and Hudson, 1993). Even though the elk were blindfolded during the procedure, the noise and the sounds of human voices were likely greater than normal during the experimental procedure. Both noise and human voices are stimuli that have been shown to elevate the heart rate and increase the movement response in domestic cattle during handling (Waynert et al., 1999).

Researchers have reported that many physiological, endocrinological and behavioural indices of stress measured post-operatively were not different between velvetted animals and uncut controls that were handled and restrained (Matthews et al., 1990; 1991; 1994). They speculated that the actual velveting procedure might be no more stressful to the stags than the handling operations required to undertake it. They did not however, suggest a way to separate the effect of handling and background stress during and after velveting from the acute effects of pain experienced from antler amputation. Prior to work by Schwartkopf-Genswein et al. (1997, 1998) the one successful way to unmask the effects from handling and observe treatment differences from branding in cattle was to use docile dairy cattle instead of beef cattle (Lay et al., 1992). Perhaps tame elk or elk habituated to handling and restraint will be necessary in separating the handling effects from the response to various antler harvesting techniques in elk.

Another possible explanation for the similar response to antler removal across all groups might be that a stress-induced analgesic (SIA) response was initiated. The phenomenon of SIA has been reported for laboratory animals (Amir and Amit, 1978; Colwell and Kavaliers, 1992) and pigs (Rushen and Ladewig, 1991). It is characterized by a reduction in pain sensitivity following a psychological or environmental stressor. An SIA response in elk has not been previously reported, but Rushen et al. (1996) did report a stress-induced analgesic response in dairy cattle following isolation. It has previously been demonstrated that the physical act of handling and restraint, plus the holding and isolation from herd mates prior to processing are contributing factors to stress in red deer (Pollard et al., 1993; Carragher et al., 1997; Grigor et al., 1999). The explanation that a stress-induced analgesic response existed in this experiment seems plausible considering 1) the wild nature of the animals 2) the methods of handling, isolation and restraint that were required and 3) the equal levels of exertion forces displayed by animals blocked via Lidocaine (an accepted and proven method of analgesia) and Control animals without exogenous analgesics administered.

Unfortunately, the response by the animals to recapture was also unable to separate treatment effects. Measuring an animal's aversion to a procedure during the subsequent handling is not always possible (Schwartzkopf et al., 1997). Rushen (1986) and Grandin et al. (1986) were successful, but only after exposing each animal to each noxious treatment several times. It is uncertain how such methodology could be applied to elk in answering questions regarding various techniques to harvest antler

Implications

This experiment failed to demonstrate an advantage of one analgesic method over another, or indeed an advantage of either method over no analgesia at all. We have postulated that this must be due to psychological factors influencing the experience or expression of pain in the experimental animals. Further studies using animals that are habituated to handling and restraint and methodologies that neutralize the confounding effects of fear and psychological stress must be devised in order to measure the presence and extent of pain resulting from antler removal.

Due to the confounding factors that were inherent to the experimental procedures used, the inconclusive nature of the results, and the speculative explanations of the results, it would be inappropriate to advocate that no pain management procedure be used during commercial velveting simply because the control group responded similarly to the experimental groups. It is possible the measurements taken were indicative of the non-specific reactions to the entire procedure rather than the discomfort experienced by the animals during the cutting of the antler. We believe the results are somewhat indicative of the relatively wild nature of the stock and the variation in restraint caused by the hydraulic squeeze. We believe we would have obtained different results had the elk been habituated to handling and restraint by the experimental crew and had a less physically and emotionally disturbing device other than a reciprocating saw been used. For this reason we believe it would be inhumane to advocate the commercial cutting of antler

using either of our control protocols, since the risk of the animals feeling pain while masking the effects seems plausible.

Authors note:
We wish to express our concern that the results of this study not be viewed as definitive. It is highly unlikely that all three treatments impact upon the animals to the same degree and it would be incorrect at this stage of our understanding to claim all three treatments have the same effect, or to say that they all had no effect on the animal.

We are fearful that the information contained in this report might be used by individuals within the industry to support their preference and by opponents outside the industry to support their opinions. Misuse within the industry could come from individuals accepting the results as proven fact, arguing that pain management is a waste of time since both analgesic treatments were no different from controls. Processing the animals as rapidly as possible without regard for anesthesia may be in fact the best solution, but it is not a method that should be advocated in today's politically correct environment nor would it be a defensible position. In the event the control animals did not feel pain, they were likely blocked by stress induced analgesia. We do not believe it would be in the best interest of the industry to suggest that it is satisfactory to block pain via fear and stress induced analgesia.

Misuse of the information by opponents of the elk industry or opponents of antler harvesting might claim the industry and procedures are inhumane because the simple act of handling and restraint of these animals is sufficient to bring about a stress response capable of blocking the pain from amputating soft antler. This argument would also be based on the acceptance of research that we believe is inconclusive and research that may have methodological shortfalls.

We remain unconvinced that this information should be used by anyone to support their view. We would not like to see this report published in popular press articles or trade magazines since we believe it opens the door to more, not less, arguing between opposing groups. We are disappointed that the results were not more definitive and hope that you share in our concern on how to best use this information.

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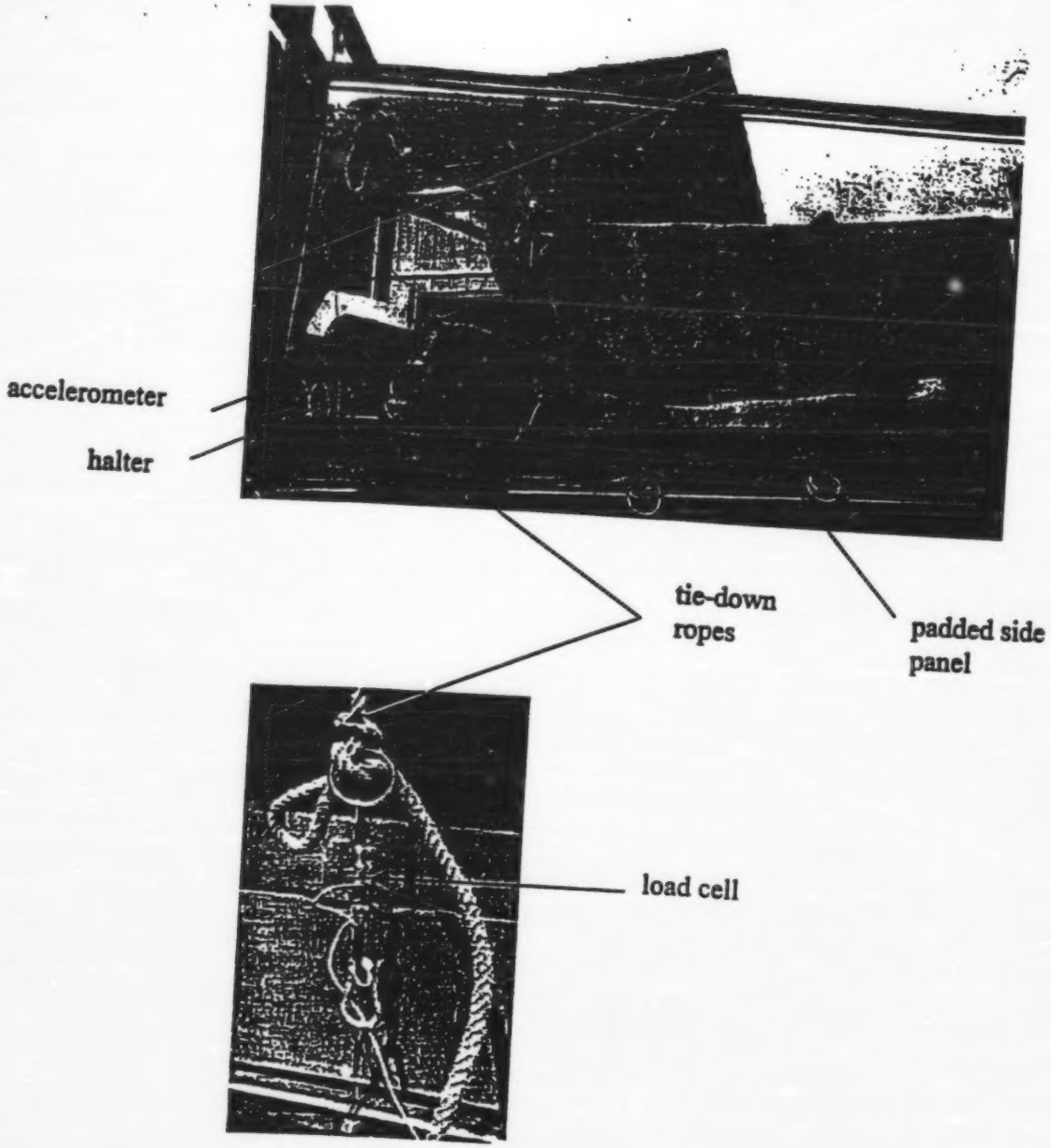

Figure 1. Animal restraint and response sensors. a) Animal restrained in chute. b) Close up of force transducer inline with tie-down rope.

Table 1. Comparative forces exerted and movement by bull elk during the harvesting of velvet antler without anesthetics or using T.E.N.S. [1] or Lidocaine block.

Treatment	n	Maximum force exerted during cutting (Newtons)		Relative movement during harvest (SD)[2]		Average time in squeeze (sec.)
		Antler 1	Antler 2	Antler 1	Antler 2	
C - 2 min[3]	10	47.5 ± 28.5	161.9 ± 140.9	25.5 ± 7.5	38.7 ± 23.5	378 ± 16
C no wait[4]	11	152.3 ± 35.4	91.5 ± 34.8	44.4 ± 9.4	25.7 ± 10.0	254 ± 18
T.E.N.S.	21	180.4 ± 58.3	73.4 ± 23.3	44.2 ± 9.5	24.3 ± 3.9	358 ± 13
Lidocaine	20	192.2 ± 68.2	240.1 ± 75.3	57.2 ± 16.7	52.9 ± 16.1	590 ± 12

[1] Refers to Transcutaneous Electrical Nerve Stimulation device designed to deliver electro-analgesia.

[2] Represents the relative struggle during the cutting of the antler. Value calculated as the standard deviation from the pre-cut baseline of all instantaneous force measurements recorded during cutting.

[3] Control treatment with antlers cut off without anesthetics after restraining the elk for 2 minutes.

[4] Control treatment with antlers cut off without anesthetics immediately after the elk was restrained in squeeze.

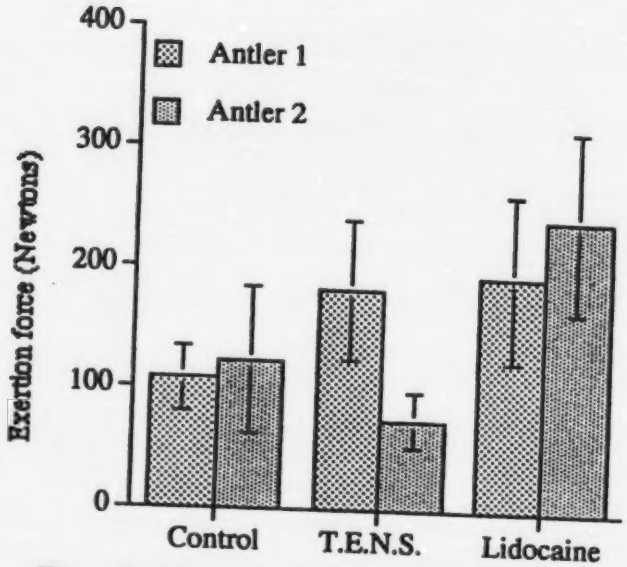

Figure 2. Maximum force exerted by bull elk during the harvesting of soft antler without anaesthetics or using T.E.N.S or lidocaine block.

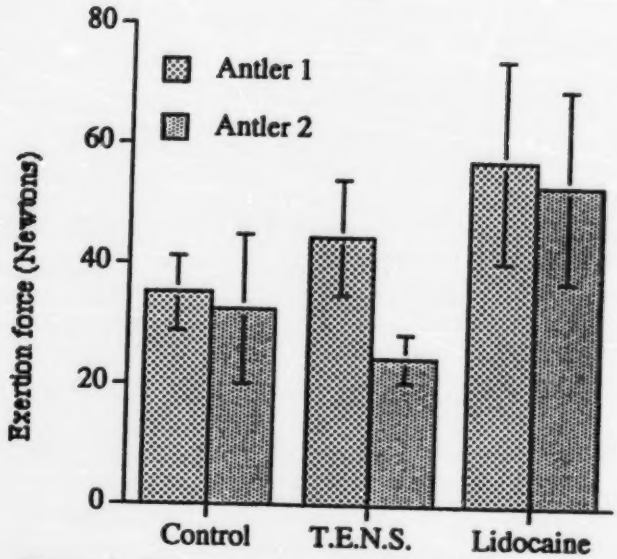

Figure 3. Relative amount of struggle by bull elk during the harvest of soft antler without anaesthetics or using T.E.N.S. or lidocaine block.

Table 2. Time to re-enter and recapture elk and response to re-exposure to saw sound within days of antler removal.

Previous Treatment	Sample size n	Time to re-enter chute (sec.)	Time to re-catch animal (sec.)	Range of force to sound of saw (Newtons)	Movement to sound of saw (SD)
Control 2 min wait	5	12.6 ± 4.56	28.8 ± 15.98	43.24 ± 14.14	8.84 ± 2.46
Control no wait	5	14 ± 8.66	3.75 ± 0.67	33.87 ± 6.47	6.93 ± 1.12
T.E.N.S.	8	18.4 ± 5.43	4.1 ± 0.91	35.96 ± 6.35	8.60 ± 2.03
Lidocaine	9	10 ± 3.25	9.67 ± 4.20	31.28 ± 5.12	7.88 ± 1.52

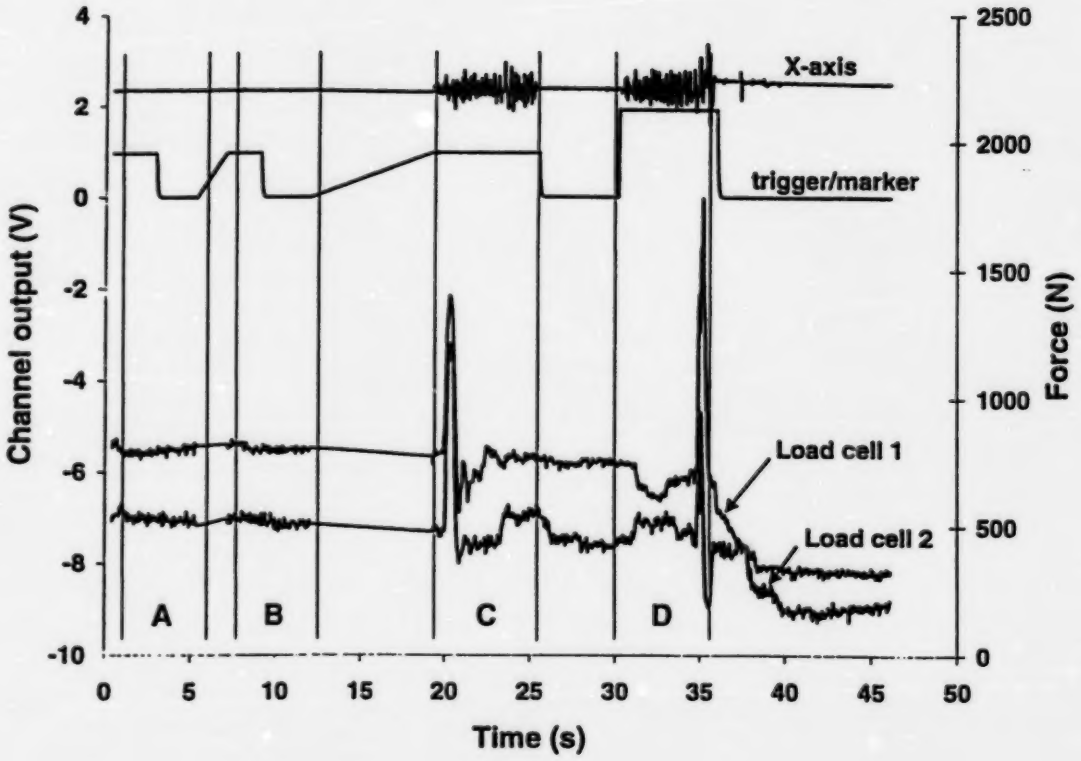

Figure 4. Typical output from the x-axis of the accelerometer and trigger/marker channel (voltage) with force histories from the 2 load cells. Interval A represents the initial 5- second baseline, interval B is the 5-second baseline with saw running and intervals C and D represent the cutting of the first and second antlers, respectively.